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RECENT ADVANCES IN PHYSIOLOGY OF REPRODUCTION OF PLANTS[1]

By Professor A. E. MURNEEK

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OUR knowledge of the physiology of sexual reproduction in plants is still rather limited and of quite recent origin. This is undoubtedly due to the fact that most higher plants are hermaphrodites and that the sexual organs are rather minute and ephemeral. It should be possible, however, to overcome this difficulty imposed by the material, at least in certain restricted phases of investigation of reproduction, by the use of large numbers of individuals, which permits the isolation of sufficient quantities of desirable tissues for a physiological and chemical assay. Then, too, the relatively small size and comparative ease of manipulation of many plants would seem to fit them to a variety of experimental observations and treatments.

For the purpose of orientation, sexual reproduction of higher plants may be subdivided into certain steps or phases, of which the following appear to be of major importance: (1) Initiation or "ripeness" of the sporophyte for reproduction; (2) chromosome conjugation (synapsis) and spore formation—the beginning of the gametophytic generation; (3) pollination and growth of the male gametophyte; (4) fertilization or union of gametes and (5) development of the embryo and its influence on the mother sporophyte.

For various reasons, which can not be taken into account here, some of these phases have been investigated more extensively or more thoroughly than others.

[1] Retiring president's address, American Society of Plant Physiologists, Atlantic City, December 29, 1936.

[2] Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 506.

On not a few the experimental evidence is still very limited and of a conjectural nature.

Initiation of Sexual Reproduction

The genetic constitution of the plant determines not only the type of reproduction but to a large extent also the time of its occurrence. We have plants of typical floral organs and late and early blooming varieties and strains in great abundance. Ordinarily these features are quite specific and stable. Consequently, it was believed for a long time that environmental factors, though effective in modifying the action of genes, were not able to delay or alter greatly the fundamental developmental sequence in plants. It was supposed to be entirely under genotypic control.

The striking results obtained by Klebs at the turn of the century showed, however, that a prolonged exposure to certain external factors, mainly light and temperature, may result in either continuous vegetative growth of plants or, contrariwise, they may be induced to become reproductive prematurely. Thereby the normal developmental sequence could be altered most markedly. Plants could be stopped and maintained at particular stages of development almost indefinitely or made to proceed through a series of stages with astonishing rapidity. According to Klebs, environmental factors have no direct effect on the protoplasm. Their action is expressed through changes in the internal environment of the plant, which in turn has a bearing on the function of the living part of the organism. He posited as the primary cause the accumulation of carbohydrates and their relative concentration in comparison to soil nutrients, especially nitrogen. During the vegetative state the plant is characterized by a relatively low concentration of carbohydrates and in the reproductive state by a high accumulation of the products of photosynthesis.

The concept of the carbohydrate-soil nutrient relationship as a factor in the initiation of reproduction in plants remained dormant for almost two decades. Possibly it came at the "wrong" time, since the biologists were then interested in the new theory of insulation of the germplasm from its environment, which was promulgated by Weismann and accepted readily.

The ideas expressed by Klebs were taken up some years later by Kraus and Kraybill, who tried to establish more definitely the carbohydrate-nitrogen relationship as a causal factor in both vegetative development and sexual reproduction of plants. It is not necessary to detail here the results of investigations supporting this idea and those contradicting it, since all students interested in plant physiology are quite familiar with them. The prevailing opinion at present seems to be that, though the carbohydrate-nitrogen ratio may have something to do with the amount of reproductive organs formed or the quantity of fruit produced, it is not the causal agent of initiation of the reproductive state. There remains the possibility, that a certain carbohydrate-nitrogen environment may be conducive to the production of a specific catalytic substance, which initiates reproduction.

That environmental factors have a striking, almost direct effect in bringing about sexual reproduction in higher plants was demonstrated by Garner and Allard through their studies of photoperiodism. No one would have suspected that so "dilute" a part of the environment as length of day would have so potent an effect on development of plants.

Studies of the nature of photoperiodism have been influenced by the fact that the response can be localized. It is not yet certain, however, whether reception of the photoperiod is restricted to the stem or to the leaves, though most of the evidence seems to point to the leaves, whence the effect is transmitted to the stem. It has been suggested that the chloroplast pigments, especially the carotinoids, may have something to do with it and that the oxidation-reduction enzymes may determine the reaction of plants to length of day.

Several investigators have demonstrated that when certain plants are grown for a definite time under one photoperiod and then transferred to another, the effect of the first exposure will appear in later development. This phenomenon has been named "photoperiodic after-effect" or "photoperiodic induction." Thus by exposure to an appropriate length of day sexual reproduction may be induced and will manifest itself, though the plant may be grown subsequently in an environment conducive only to vegetative growth. Instances are on record where as few as 4 to 6 days have been sufficient for induction of reproduction.

The causal mechanism of photoperiodic induction as that of photoperiodism itself is unknown. It is possible that irreversible changes are brought about during the period of induction in the protoplasm of the growing points, which speeds up the development of the plant. There is clear-cut evidence that a certain "dosage" or number of days are required to induce *fully* the initiation and growth of the reproductive organs. Treatments short of this necessary minimum will result in incomplete or partly vegetative flowers. The mechanism of photoperiodism, therefore, is not "trigger-like" in its action, as has been suggested. Very likely it exerts itself through the formation of certain hormone-like substances, the quantitative accumulation of which results eventually in the development of reproductive organs.

Much activity has been displayed during the past few years in studies of the relation of temperature to photoperiodism and more lately on the direct effects of temperature on sexual reproduction of plants. Of

greatest interest at present is not the fact that temperature may modify the formative effects of the photoperiod, but that this environmental factor itself may be as potent in induction of reproduction as the light period. The extensive investigations by Thompson and his coworkers show that as small differences as 6–10° F. will either suppress or stimulate the formation and development of floral organs.

Apparently the length of day is not the only external factor that may cause the initiation of sexual reproduction. Plants seem to be more sensitive to environmental conditions than we have suspected. It is probable, therefore, that there may be other external agencies yet to be discovered, which, at least under certain circumstances and with particular groups of plants, may be as effective as photoperiods and temperature in their influence on development.

A quite unsuspected approach to physiology of reproduction of plants has been made through studies of *vernalization*—a treatment given to seeds previous to sowing to hasten the time of flowering. This procedure, though suggested by Gassner, was initiated by Lysenko. By exposing partly swollen seeds to definite temperature, depending on the species, an induction of reproduction is obtained, which is very similar to photoperiodic induction or after-effect. This treatment itself, however, will not make plants reproductive unless during their subsequent development they are exposed to a suitable length of day. Many plants, therefore, have to pass through two, possibly more, stages or phases of internal readjustment—the thermo- and the photo-phase at least—before they become sexually reproductive.

The extensive investigations on vernalization and speculation as to the essential nature of the response of plants to this treatment has led Lysenko to a conception known as *"phasic development."* Though this author postulates a strict succession in development, it would seem that in *Soja* and possibly other species vernalization implies the completion of both phases (thermo and photo) more or less concurrently. Of significance in this connection is the suggestion that it may be possible to vernalize by light only and that some seeds may become vernalized while still connected with the mother sporophyte.

From the results of recent studies the striking fact emerges that it is possible to initiate reproduction in a very early stage in the development of the plant—while it is in the seed. Hence some phases of the physiological studies of sexual reproduction, perforce, will have to be moved back to the seed stage of the plant.

Since no flower primordia are present in this extremely early period of development, the after-effect from vernalization, and most probably from photoperiod also, must express itself through alteration in the physiological state of the whole or some parts of the embryo plant. This would seem to suggest a chemical substance, possibly of catalytic nature, as the causal factor bringing about these results.

Changes produced in cells of plants in the embryonic stage as a result of vernalization seem to be transferred to other cells produced from them, but not translocated to other parts of the same plant. This appears to be true for both the thermo- and the photophase.

Vernalization during the thermo-stage may be given in instalments as it were: half of the total exposure now, then seeds dried, and the other half later. The results from the treatment are additive. Hence the influence exerted by temperature appears to be of the nature of gradual quantitative effects. Recent evidence suggests that the effects from a photoperiod are also of a "quantitative" nature and that a time factor exists for the accentuation of the induced changes. By a careful regulation of the period of exposure to certain lengths of day, one may obtain various types of development between vegetative shoots and normal flowers. This, again, seems to point to a chemical hormone-like substance as the causal agent.

Once reproduction is initiated, it proceeds through more or less definite morphogenetic stages—synapsis and the formation of spores, gametogenesis, pollination, fertilization, embryo development and its ripening into a seed. Naturally the mother sporophyte participates in, is part of and is affected by the special morphological development and physiological changes during the reproductive cycle.

Synaptic or Chromosome Conjugation Stage

This very important phase in the alternation of generations of plants is not reserved solely for the study of geneticists, though they have developed a very profound technique and a respectable vocabulary for the analysis and interpretation of certain very important features of it. If during gametic union or fertilization there is a physiological stimulation, which results in rapid development of tissues accessory to the embryo and may stimulate other parts of the plant, then one should expect also a physiological effect during chromosome pairing or conjugation at synapsis, which is supposed to be the final stage or completion of fertilization. This idea was expressed by the speaker some time ago, though the experimental data to support it were limited.

A spurt in growth of various parts of the plant in proximity to the developing flower buds is a familiar phenomenon. It is somewhat difficult to say wherein lies the exact cause of this stimulation. Circumstantial evidence seems to point to the synaptic stage of reproduction as the period of initiation of this accelera-

tion in growth. Vöchting and Fitting have studied experimentally the relationship between the flower bud and growth of adjoining tissues. More recently Katunsky has analyzed the problem histologically and has pointed out the existence of a correlation between the development of primary reproductive tissues and the accessory organs. In *Papaver* and *Crepis,* for example, the stages in growth and movement of the pedicels correspond with definite phases of the development of the female gametophyte. Two maxima could be observed. The first occurred during the development of the nucellus, the second and larger spurt in growth took place at the approximate time of reduction division and spore formation. Rate of cell division and growth in both instances is thought to be due to the production of a growth-promoting hormone by the pistil, more specifically by the developing ovule.

Pollination and Growth of the Microgametophyte

The germination of pollen grains and growth of pollen tubes seems to be controlled not only by environmental factors and the nutrient supply of the stigma and style but also by specific accessory substances. These may be either catalytic or inhibitory in nature or both. To what extent the production of these regulators is subject to the genic constitution of the plant and how much it is determined by the internal physiological environment is still an open question. That the growth of the pollen tubes through the style has a stimulating effect on the gynoecium has been known for a considerable time. In the absence of fertilization, the fruit frequently develops parthenocarpically as a result of this stimulation.

A more concrete demonstration of this effect has been supplied by Gustafson, who has been able to induce parthenocarpy by pollen extracts and, what is more interesting, by the application of growth-promoting chemicals (indole and phenyl derivatives) to the cut surface of the style just above the ovary. This makes it quite evident that definite substances are released by either the microgametes or the microgametophytes. These do not seem to be specific and may be related to the auxins. However, one is obliged to view with reservation a too wide application of the few plant hormones known at present.

Of interest in this connection are the investigations by Fitting, who has demonstrated that in some plants, especially orchids, the petals and other floral parts undergo senescence and death soon after pollination and long before fertilization has occurred. In the absence of pollination the flowers will not die for some time. The wilting of flowers thus seems to be due to the secretion of certain substances by the pollen. Such an effect is obtained also when pollen of a species incapable of accomplishing fertilization is applied to the stigma.

It is possible that in some instances the presence of the male gametophyte in the style results in parthenogenesis—the development of the embryo without fertilization. The conspicuous results obtained by artificial (chemical) fertilization of eggs in animals suggests such a possibility.

Fertilization and Formation of the Zygote

There is considerable experimental evidence at hand showing the influence of fertilization on the physiology and morphology of plants. It is commonly known that normally the accessory tissues making up the fruit are able to develop only in the presence of one or more embryos. If fertilization has not taken place and the zygote is not formed, the fruit will grow but little and will abscise while still immature. Exceptions to this rule, of course, are cases of parthenocarpy, referred to already.

As a result of the act of gametic union, and hence immediately following fertilization, there is a marked increase in metabolism in tissues adjoining the embryos. It is not known as yet whether nuclear division of the endosperm is also stimulated by the presence of the embryo. This 3n generation may have its own high metabolic gradient. The nucellus and the integuments are certainly affected by the embryo, in the absence of which they usually do not develop and undergo atrophy a few days after pollination (*Pyrus,* etc.).

Of interest in this connection is the possible fact that in *Citrus, Mangifera* and other species, the presence of the embryo may lead to proliferation of nucellar tissue resulting in production of apogamic embryos. It is not clear, however, whether apogamy is caused by stimulation produced by the embryo or, somewhat earlier, by the macrogametophyte.

Stimulation from the embryo naturally extends to ovarian and other tissues making up the fruit, which will be either large or small, regular or irregular in form, and altered in chemical composition, depending on the number, size and position of embryos present. These well-known facts to the botanist and horticulturist have been submitted recently to experimental verification by Tukey, who has demonstrated in various ways that the development of stone fruits is affected by the embryo. In this relationship between the seed and the pericarp the stage of development of the embryo seems to be one of the main factors.

In discussing the effects of fertilization on growth of tissues of the mother sporophyte, one should not lose sight of an important genetic aspect. The increased or decreased heterozygosis, resulting from certain pollinations, frequently has an observable and measurable influence on the size and composition of

the pericarp and accessory tissues of the fruit. This has been demonstrated with the date, cotton, legumes and several other plants. The phenomenon has been named *metaxenia,* thus separating it from xenia, the visible genetic influence on the endosperm of monocots or cotyledons of dicots.

In many plants (*Tussilago, Digitalis, Althea*) the greatest growth of the flower stem occurs after fertilization. It ceases when cell division of the embryo is completed. In some cases fertilization is essential for the growth and movement of the pedicels and other floral parts. Effects obtained from pollination do not seem to bring about these changes.

Stimulation due to sexual reproduction seems to extend for some distance beyond the reproductive organs and probably throughout the organism. The speaker has found that in the tomato (*L. esculentum*) the development of embryos and accessory tissues influences the whole metabolism of the plant. As a result of gametic union and formation zygotes, both absorption of soil nutrients and assimilation of carbon dioxide are increased. It is possible to measure this effect only when the number of embryos per plant is quite large and the fruit is removed shortly after fertilization. This procedure prevents the masking of the effect by changes brought about by the "metabolic drain" or monopolization of various substances by the rapidly developing fruit.

Though a general stimulation may accrue from fertilization, it is quite clear that the fruits obtain an incomparably greater profit from it. The rest of the mother sporophyte receives but a temporary exhilaration, as it were, the benefits of which go eventually and often entirely to the developing seeds and fruits. Once the largest number of embryos have been formed under the existing conditions of nutrition, almost all the synthesized and a large part of the directly absorbed substance are incorporated into the fruits—the organs directly associated with the life of the embryos.

What are the means by which the embryos are able to draw to themselves and adjoining tissues the available food supply? In light of the present experimental evidence one is obliged to postulate a mechanism of a specific enzyme or hormone character. At certain stages of growth the embryos may secrete a hormone or hormones, which may regulate metabolism and direct development. The suggestion of an endogenous system of secretions is in line with the newer knowledge of plant physiology.

Effects of Embryo Development on Mother Sporophytes

One of the most striking features of physiology of reproduction of higher plants is the diversion or localization by the embryo of the products of assimilation. As a result of this draft on the available food resources of the plant all sorts of inhibitions, disarrangements and even destruction of certain parts of the parent organism may take place. In species with a continuous type of growth, like the tomato, a maximum crop of fruit results in curtailment of growth and development in approximately the following order: (1) Sterility of blossoms; (2) decrease in size of flowers and the inflorescence; (3) abortion of flower buds; (4) reduction and cessation of terminal growth of stems and branches; and eventually (5) complete exhaustion and death of the plant, save the fruit.

Since the number of seeds and fruits formed does not always overtax the capacity of the plant to support, there may not be a very noticeable effect or only a temporary curtailment in growth and development or in flowering and fruiting. As soon as the fruit crop has absorbed all the required nutrients, growth is resumed. This may cause cyclic development and fruiting, which is exhibited by many groups of plants. Alternate bearing of fruit trees, periodic flowering, cyclic sterility, etc., are phenomena that may be traced back to the effects of crops of seeds and fruits on the metabolism of the plant.

It is not known for certain what particular substances may be exhausted first by the reproductive organs and thus act as limiting factors. There are several reasons to believe that frequently nitrogen may be the first limiting factor: (1) Seeds and young fruits are organs of relatively high nitrogen content. (2) Nitrogen frequently runs short in rapidly growing plants. (3) A crop of fruits inhibits growth and changes development in a manner that is symptomatic of nitrogen starvation. (4) Plants of low nitrogen content are affected sooner than those abundantly supplied with this element. (5) Ample nitrogen nutrition will delay the "detrimental" effects until additional fruits are formed and the "load" has reached again the capacity of the plant to support.

Naturally other organic substances, especially the carbohydrates, under certain conditions may be the limiting factors. While during the early stages of growth the fruit absorbs much nitrogen, later on it accumulates mostly carbohydrates.

The speaker is fully aware of the fact that he has attempted to cover a very broad and still little studied subject of plant physiology, that he has neglected entirely the lower plants and that he has omitted certain phases of physiology of reproduction of the spermatophytes. The time and his own interests have to some extent limited this discussion. Let us hope that in the future more attention will be paid to this phase of the life of plants, that in summarizing our knowledge of plant physiology there will be a substantial fund of more exact information on the physiology of reproduction of higher plants.

SCIENTIFIC EVENTS

THE ANNUAL VISITATION DAY OF GREENWICH OBSERVATORY

THE Board of Visitors of the Royal Observatory assembled at Greenwich on June 5 to make the annual visitation and receive the report of Dr. Spencer Jones, the Astronomer Royal. The members of the board are the president and six fellows chosen from each of the Royal and the Royal Astronomical Societies, the Savilian professor of astronomy at the University of Oxford, the Plumian professor of astronomy at the University of Cambridge and the hydrographer of the Admiralty, almost all of whom were present.

According to the London *Times*, the report opens with the statement that the Nautical Almanac Office has been placed under the direction of the Astronomer Royal and has been made a branch of the Royal Observatory. The Nautical Almanac was established by Nevil Maskelyne, the fifth Astronomer Royal (1765–1811), to give astronomical information necessary for navigation in a convenient form, and it seems likely that the first issue, which was for the year 1767, and those immediately following were prepared within the Royal Observatory. Though this practice was changed, the Astronomer Royal was responsible for the publication until the year 1831, and the Almanac for 1834 was signed by another as superintendent.

The *Times* points out that the present reversion to the earlier system evidently adds much to Dr. Spencer Jones's responsibility. Four pages of the report deal with matters connected with the office, one of them being the compilation of a special Air Almanac and Altitude-Azimuth Tables for the Air Ministry that is proposed. The purpose of this almanac will be to make possible the navigation of aircraft by astronomical observation.

The home of the Nautical Almanac Office remains as it has been for some years past in the Royal Naval College, below the hill on which the observatory stands, but the names of its staff are included for the first time with those of the observatory in the report. D. W. Sadler, the new superintendent, who receives special commendation, ranks as a chief assistant.

In Dr. Spencer Jones's first report, that for 1933, he spoke of two important new telescopes that he had inherited from his predecessor but which at that time were still in the workshops of their respective makers. They are now in the Christie enclosure in Greenwich Park, and about them he reports progress. As to the new reversible transit circle provided by the Admiralty to take the place eventually of the instrument erected by Airy in 1851, some final figuring of the pivots has been found necessary, the utmost precision being essential in this particular, and has been successfully performed by the makers. Various other improvements have been effected and additions made and the instrument has been used successfully since last September. The observation of stars by reflection at a mercury level surface, which has been a feature of the operations at Greenwich for the past hundred years and has been the object of much discussion, has been given up. The other new instrument is a 36-inch reflecting telescope, equatorially mounted, presented to the Royal Observatory by Johnston Yapp.

Another recent gift is a free pendulum clock of the Shortt type but with some improvements, presented by H. R. Fry, of West Stoke. The report states that a quartz crystal oscillator clock is to be supplied, with the help of Dr. E. H. Rayner, of the National Physical Laboratory, to ensure the accuracy of the distributed time-signals in the event of a long period of cloudy weather when it is impossible to make star observations.

The program of double-star observing with the 28-inch refractor has been reorganized. It has seemed desirable that the instrument should be put to a more general remeasurement of all pairs rather than to those which are peculiar on account of great magnitude difference or of small separation between their components, and the result has been a large increase in the number of observations. The 26-inch refractor has been used as heretofore for taking photographs for determining stellar parallax, and a device, due to Dr. Schlesinger, of Yale, was on view in a screened-off compartment in one of the computing rooms of the observatory to facilitate the measuring of photographs.

THE NATIONAL PARKS ASSOCIATION

AT the recent meeting of the trustees of the National Parks Association, Dr. Henry B. Ward, vice-president of the association, gave a full discussion on the subject of the proposed irrigation tunnel through Rocky Mountain National Park and presented in behalf of the legislation committee the following resolution which, being duly seconded, was passed as follows:

The National Parks Association in its annual meeting on May 14, 1937, noting the recommendation of the Reclamation Service that an irrigation tunnel and conduit be constructed under the Rocky Mountain National Park, hereby records its opposition to the proposition for the following reasons:

1. Use of this park for commercial purposes would create a precedent in defiance of the standards which have been set up by Congress during the past twenty years and lay the National Park System open to economic exploitation.

2. We are convinced that construction of the proposed tunnel and conduit is bound to alter natural conditions on the surface in the vicinity and to impair or destroy the primitive values of the Park.

3. Other routes are known to be available which can be used without endangering the Park.

We call upon all agencies concerned with the protection of our unique system of National Primeval Parks to unite in firm opposition to the threat to Rocky Mountain National Park and through it to the entire system.

Dr. William S. Cooper, as chairman of the special inter-association committee on Glacier Bay, reviewed the history of the bill permitting mining within the Glacier Bay National Monument and pointed out that only a few prospectors had taken advantage of their right to prospect within this monument because of the fact that past experience had proved it to be quite barren of any large deposit. Dr. Cooper also pointed out that, in so far as defacement of the monument itself is concerned, mining rights would not seriously affect it. But he stressed the point that this bill opening Glacier Bay to mining had created a precedent for possible Congressional action in the future along the same lines with respect to other national monuments and national parks. The question of attempting to repeal the bill in this session of the Congress was not considered feasible by Mr. Cooper, and he suggested that the committee remain intact, but that for the present at least it should mark time.

MILTON AND CLARK AWARDS OF HARVARD UNIVERSITY

FORTY-NINE awards, amounting to $47,760, have been assigned to members of the Harvard teaching and research staffs under the provisions of the wills of William F. Milton, '58, and Joseph H. Clark, '57. These grants are made annually to aid in defraying the expenses of special investigations during the coming academic year. Awards have been made as follows for 1937 in the natural and exact sciences:

Lawrence W. Baker, professor of orthodontia, to continue studies regarding the masticatory apparatus as a growth center of the bones of the face and as an inductor of growth of the other bones of the skull.

Thomas Barbour, professor of zoology and director of the University Museum and of the Museum of Comparative Zoology, and Alfred S. Romer, professor of zoology and curator of vertebrate paleontology at the Museum of Comparative Zoology, to prepare skeletons of primitive reptiles collected in South America.

Paul D. Bartlett, instructor in chemistry, to "mark" atoms by the use of artificially induced radioactivity for facilitating the study of molecular structure.

Bart J. Bok, assistant professor of astronomy, to continue an investigation of the objective prism radial velocities of faint stars.

William J. Clench, curator of mollusks in the Museum of Comparative Zoology, for a zoological survey of northeastern Hispaniola, particularly as regards mollusks.

Lemuel R. Cleveland, associate professor of zoology, for a study of the protozoa of termites, with particular reference to the function of the centrioles in chromosomal movement and the production of extra-nuclear organelles.

Joseph A. Cushman, lecturer on micro-paleontology, for a study of the foraminifera found in deep sea cores from the Atlantic Ocean.

Philip J. Darlington, Jr., assistant curator of insects in the Museum of Comparative Zoology, to extend the applicant's collection of insects, especially beetles, and study their habits and distribution on certain West Indian islands.

Walter F. Dearborn, professor of education and director of the Psycho-Education Clinic, for the preparation of statistical materials bearing on the mental and physical growth of public-school children.

Merritt L. Fernald, Fisher professor of natural history and curator of the Gray Herbarium, for botanical exploration in Virginia and North Carolina to throw significant light on the history of life in North America since the uplift of the cretaceous peneplain.

Louis F. Fieser, associate professor of chemistry, for an investigation of cancer-producing hydrocarbons.

Russell Gibson, assistant professor of economic geology, for a regional study of tin and tin-silver deposits in the Eastern Andes of Bolivia.

Ralph R. Hultgren, instructor in metallurgy, to purchase a photodensitometer for the measurement of x-ray spectra dealing with crystal structure.

Frederick V. Hunt, instructor in physics and communication engineering, for an investigation of auditorium acoustics by means of steady-state transmission measurements.

Clyde E. Keller, instructor in ophthalmic research, to investigate inheritance of blood groups in rabbits.

Karl O. H. Lange, research associate at the Blue Hill Observatory, for an investigation of thunderstorm structures by small balloons equipped with radio-meteorographs.

Harry R. Mimno, assistant professor of physics and communication engineering, for an investigation of methods of improving the operating efficiency of the cyclotron.

Gregory Pincus, assistant professor of general physiology, for an investigation of the developmental physiology of mammalian eggs.

Edward K. Rand, Pope professor of Latin, to prepare for publication an edition of Servius's "Commentary" on Virgil and an edition of Ovid's "Metamorphoses."

Theodore E. Sterne, lecturer on astrophysics, for the development of improved apparatus for the radiometric photometry of celestial objects.

Henry C. Stetson, research associate in paleontology at the Museum of Comparative Zoology, for the construction of a duplicate of the coring tube redesigned by C. S. Piggot, of the Geophysical Laboratory, for taking cores of the ocean bottom.

S. Smith Stevens, instructor in psychology, for the investigation of the psycho-physiology of frequency modulation and transient phenomena in normal human beings and in animals.

Theodore J. B. Stier, assistant professor of physiology, for a study of the reactions involved in the chemosynthesis of carbohydrates, fats and proteins in living cells.

George L. Stout, lecturer on design and keeper of the Ross Study Series, for the detection of the radioactivity of lead used in works of art as an index to their age.

Y. Subba-Row, teaching fellow in biological chemistry, for the chemical isolation of vitamin B_2 and other essential fractions which appear to be effective in the cure of certain diseases.

John H. Talbott, instructor in medicine, for an investigation of metabolic diseases associated with a disturbance of electrolyte equilibrium.

Morgan Upton, assistant professor of general physiology, for an investigation of the relationship between the activity of peripheral receptor mechanisms and the central nervous system with special reference to sound as the determining physical factor.

George Wald, instructor in biology, for a spectroscopic investigation of the chemistry of the retinal processes.

John H. Welsh, instructor in zoology, and Fenner A. Chace, Jr., Alexander Agassiz fellow in oceanography at the Museum of Comparative Zoology, to continue a study of the eyes of deep sea crustaceans.

E. Bright Wilson, Jr., assistant professor of chemistry, for a study of the thermodynamic properties of certain organic compounds by the measurement and interpretation of their spectroscopic properties.

Morton F. Yates, instructor in operative dentistry, for an investigation of the lymphatic drainage of the teeth.

RECENT DEATHS AND MEMORIALS

DR. RALPH D. BEETLE, professor of mathematics at Dartmouth College, died on July 9 at the age of fifty-one years.

ARTHUR B. CLAWSON, physiologist in charge of stock-poisoning plant investigations of the Bureau of Animal Industry of the U. S. Department of Agriculture, died on June 30 at the age of fifty-nine years.

THOMAS MATHER, emeritus professor of electrical engineering at the Imperial College of Science and Technology, London, died on June 23 at the age of eighty-one years.

FRIENDS and students of the late Professor Charles E. Mendenhall, of the University of Wisconsin, have subscribed a fund to found a fellowship in his memory. It has been accepted by the university and will be called the Charles E. Mendenhall Fellowship and be tenable by graduate students in experimental physics.

SCIENTIFIC NOTES AND NEWS

THE autumn meeting of the National Academy of Sciences will be held at the University of Rochester on October 25, 26 and 27. Members will be welcomed on Monday morning by Dr. Alan Valentine, president of the university, and Dr. Frank R. Lillie, president of the academy, will respond. On Monday evening there will be a special concert in the Eastman Theater by the Eastman School of Music. On Tuesday evening the subscription dinner will be held at the Genesee Valley Club. Visits will be arranged to the works of the Bausch and Lomb Optical Company and of the Eastman Kodak Company.

THE *Journal* of the American Medical Association states that Dr. Edward W. Archibald, professor of surgery and director of the department of surgery of the faculty of medicine of McGill University, was presented at a recent meeting at the Boston Medical Library with the Henry Jacob Bigelow Medal of the Boston Surgical Society. Dr. William C. Quinby, Boston, president of the society, made the presentation, and Dr. Archibald spoke on "French Surgery in the First Half of the Nineteenth Century." Under the will of William Sturgis Bigelow, in memory of his father, a sum of money was presented to the society, "the income of which is to be used from time to time for the presentation of a gold medal to some outstanding surgeon for his work in the advancement of the science of surgery."

THE first Fraser Muir Moffat Gold Medal of the Foundation of the Tanners' Council Research for "outstanding service to the leather industry" was presented to George D. McLaughlin at the annual meeting of the American Leather Chemists' Association. The presentation was made by Dr. Fred O'Flaherty, research professor of the Graduate School of Arts and Science of the University of Cincinnati. On the face of the medal is a likeness of the late Fraser M. Moffat, who for many years was president of the Tanners' Council and who was instrumental in the establishment of the Tanners' Council Research Laboratory as a unit in the Institute of Scientific Research at the University of Cincinnati.

PROFESSOR C. O. REED, of the department of agricultural engineering of the Ohio State University, was awarded, at the recent meeting at the University of Illinois of the American Society of Agricultural Engineers, the McCormick Medal for outstanding work during the year.

THE Gold Medal of the South African Medical Association for distinguished service rendered to the profession in South Africa has been awarded to Dr. W. T. Davies, for many years president of the South Africa Medical Council.

AT the commencement of Denison University the honorary doctorate of science was conferred upon Herbert Grove Dorsey, of the U. S. Coast and Geodetic Survey, and upon Warner W. Stockberger, in

charge of drug, poisonous and oil plant investigations in the Bureau of Plant Industry of the U. S. Department of Agriculture.

DAVIDSON COLLEGE, at its centennial celebration on June 8, conferred the degree of doctor of science on Lieutenant Colonel James Stevens Simmons, Medical Corps, U. S. Army, stationed at Boston.

THE degree of doctor of science has been conferred by Monmouth College on Dr. Howard H. Martin, chairman of the department of geography at the University of Washington. Dr. Martin is the retiring president of the Association of Pacific Coast Geographers and institute geographer on the staff of the Institute of World Affairs.

DR. M. A. PARKER, of the department of chemistry of the University of Manitoba, has retired with the title of professor of chemistry emeritus.

WILHELM SEGERBLOM retires from active teaching at the end of the present school year, having served on the faculty of the Phillips Exeter Academy for thirty-eight consecutive years, most of the time as head of the department of chemistry. He expects to devote himself to editorial work and to research in chemical education.

DR. PAUL S. BURGESS has resigned as president of the University of Arizona to return to his former position as dean of the College of Agriculture and director of the Agricultural Experiment Station. He will be succeeded by President Alfred Atkinson, of the Montana State College.

DR. WALTER EDMOND LEVY, professor of obstetrics in the Graduate School of Medicine at Tulane University, has been appointed professor of obstetrics and head of the department of obstetrics in the newly organized Graduate School of Medicine of the Louisiana State University.

PROFESSOR W. LÖFFLER, director of the polyclinic at Zurich, has been nominated to succeed Professor O. Naegeli in the chair of clinical medicine of the University of Zurich.

M. ORCEL, assistant director of the laboratory of the Museum of Natural History, Paris, has been appointed professor of mineralogy to take the place of M. Lacroix, who has retired.

DR. DONALD C. BALFOUR, associate director of the Mayo Foundation, Rochester, was appointed director on July 1, to succeed Dr. Louis B. Wilson, who has become director emeritus.

DR. J. ALFRED HALL, senior biochemist at the Forest Products Laboratory, Madison, Wis., has been appointed associate director of the California Forest and Range Experiment Station at Berkeley.

DR. WALTER L. TREADWAY, assistant surgeon general of the U. S. Public Health Service, is at the head of a delegation of five Americans who will attend the International Congress on Mental Hygiene, meeting in Paris from July 19 to 24. The only paper to be read by a member of the delegation will be one by Professor Walter R. Miles, of the Institute of Human Relations at Yale University, who will speak on "Prophylaxis in Alcoholism."

DR. BENJAMIN F. HOWELL, of Princeton University, associate curator of the department of geology and paleontology of the Academy of Natural Sciences of Philadelphia, sailed from New York on June 16 to represent the academy at the seventeenth International Geological Congress and at sessions of the International Paleontological Union, to be held in Moscow from July 19 to 26. While in Europe he will carry on research work in the British Museum and at the University of Oslo, as well as field work in Norway, Russia and Italy. Dr. Benjamin Miller, of Lehigh University, known for his work on ore deposits, will also represent the academy at the congress.

ALFRED C. WEED, curator of fishes at the Field Museum of Natural History, left on July 6 for the North Atlantic Coast to collect fish for a habitat group at the museum. Leon L. Pray, taxidermist, is his assistant.

ACCORDING to a wireless dispatch to *The New York Times*, dated June 28, Dr. Richard Flint, of the department of geology of Yale University; Dr. Henry J. Oosting, professor of botany at Duke University, and Dr. Flint's assistant, Albert L. Washburn, left Helsingfors on June 28 for a six weeks' geological exploration of Greenland. Miss Louise A. Boyd, of San Francisco, is the leader of the expedition and will defray its cost. She, with James M. LeRoy, hydrographer, will meet the rest of the party at Tromsö. During his visit to Finland, at the invitation of the Finnish Geological Association, Dr. Flint and his associates made geological investigations in South Finland that might facilitate the work on Greenland glaciers.

AN expedition that will last three months left Leith, Scotland, for the Arctic regions on June 27, to investigate the cosmic rays by means of balloons. Investigations will be made at very high altitudes within 10 degrees of the north magnetic pole near Baffin Bay. In addition, investigations are to be conducted by T. T. Paterson and T. C. Lethbridge on the ancient Eskimo civilization of Greenland, Ellesmere Land and Baffin Land. J. M. Wordie, senior tutor of St. John's College, Cambridge, is the leader of the expedition. Other members include Dr. Hugh Carmichael, of St. John's College, Cambridge; E. J. Dymond, H. I. Drever,

A. H. Robin, I. M. Hunter, D. Leaf and R. W. Feachem.

DR. GEORGE D. BIRKHOFF, professor of mathematics at Harvard University, during his recent visit to Paris, gave on June 4 and 5 two conferences at the Institute Henri Poincaré. He spoke on analytic functions and on unsolved problems of dynamics.

AT a meeting commemorating the semi-centennial of the founding of the Denison Scientific Association, held on June 12, under the general topic "Contributions of Science to Human Welfare," addresses were made by Dr. Herbert Grove Dorsey, of the U. S. Coast and Geodetic Survey; Professor C. Judson Herrick, of the University of Chicago, and President William E. Wickenden, of the Case School of Applied Science.

THE fifty-first annual convention of the Association of Land-Grant Colleges and Universities will be held in Washington, D. C., from November 14 to 17. A part of the convention period will be devoted to the observance of the seventy-fifth anniversary of the Morrill Act, of the act establishing the U. S. Department of Agriculture and of the fiftieth anniversary of the Hatch Act.

THE Pacific Coast convention of the American Institute of Electrical Engineers will be held at Spokane, Wash., from August 31 to September 3.

THE First International Colloquium on Endocrine Glands in Relation to Reproduction was held in the Collège de France, Paris, from June 10 to 19, under the auspices of the Singer-Polignac Foundation. Opening addresses were made by MM. Bédier and Faral and by Professor P. Bouin, of Strasbourg, who presided at the meetings. Dr. Lucien Brouha, of Liège, was general secretary and interpreter. Among those who presented papers were Drs. Edgar Allen, of Yale University; Carl G. Hartman, of the Carnegie Laboratory of Embryology, Baltimore; F. L. Hisaw, Harvard University; P. E. Smith and A. E. Severinghaus, Columbia University; H. Selye and C. S. McEwen, McGill University. The Singer-Polignac Foundation was established for the support of scientific research in 1928 by the American-born Princess de Polignac in honor of the late Prince Edmond de Polignac. The officers of the foundation are: *honorary president,* Princess Edmond de Polignac; *president,* M. Joseph Bédier, chancellor emeritus of the Collège de France; *executive secretary,* M. André Mayer, Collège de France; *members of the council,* MM. Maurice Paleologue, Edouard Estaunie, Georges Maringer, Paul Léon, Edmond Faral and Emmanuel Fauré-Fremiet. The proceedings of the meeting will be published in book form.

THE *Experiment Station Record* states that under a memorandum of April 9, 1937, an Advisory Committee on Research of the U. S. Department of Agriculture has been set up by Secretary Henry A. Wallace, consisting of F. D. Richey, H. G. Knight, J. R. Mohler and L. A. Strong, chiefs, respectively, of the Bureau of Plant Industry, Bureau of Chemistry and Soils, Bureau of Animal Industry and Bureau of Entomology and Plant Quarantine, and E. N. Bressman, of the Agricultural Adjustment Administration. This committee will advise the secretary and director of research on such specific research problems as may be assigned them from time to time. It will also, upon its own initiative, survey the field of research within the department with a view to developing uniform research project systems and obtaining an able research personnel. The *Record* points out that the appointment by transfer from the Soil Conservation Service of Merrill Bernard, hydraulic engineer, to succeed M. W. Hayes, deceased, as chief of the River and Flood Division of the Weather Bureau marks a new departure of the bureau, namely, the selection of a hydrologist rather than a meteorologist to head one of its important divisions, the severe floods of the last few years having shown the need of specialists in hydrology in the task of developing new flood-forecasting methods.

THE *Journal* of the American Medical Association reports that the project for construction of a new building for the Faculty of Medicine, Buenos Aires, at a cost of $3,500,000, has been approved by the government. The government has asked the university to cut down expenses by twelve per cent. It is requesting, however, the same allowance for expense that it had in 1930, which has been cut down from that year up to the present by forty-seven per cent.

DISCUSSION

THE SCHÜTZ-BORISSOV LAW FOR ENZYMES

IT is frequently stated by investigators and writers on enzymes[1,2] that for preparations of certain enzymes, *e.g.*, pepsin, the velocity of reaction has been found to be proportional to the square root of the enzyme concentration. Reference to the original data

[1] J. B. S. Haldane, "Enzymes, Monographs on Biochemistry," p. 11, London and New York, 1930.

[2] S. Waksman and W. C. Davison, "Enzymes," p. 44, Baltimore, 1926.

upon which this law was based, that of E. Schütz[3] in 1885 and the confirmatory data of Borissov[4] in 1891 and J. Schütz[5] in 1900 shows merely that in the presence of varying concentrations of pepsin, the *amounts of protein digested at a given time* (*e.g.*, 16 hours in the work of E. Schütz) are proportional to the square root of the enzyme concentration. In so far as the Schütz-Borissov formulation limits itself to the summary of these particular results or similar results for other enzymes, it is correct, though naturally quite limited in its significance.

That formulation, however, of the Schütz-Borissov or of similar data which aim at wider significance by stating that the *velocity of reaction* is proportional to the square root of the enzyme concentration is based on an incorrect use of the term "velocity of reaction." This error is easily revealed by mathematical treatment of the kinetics of the reaction involved, and it may be shown that E. Schütz's own data support the general rule, established so widely for other enzymes, that the reaction velocity is directly proportional to the first power of the concentration of enzyme.

E. Schütz determined the extent of action at only one point, 16 hours, submitting no data on the course of the reaction. Arrhenius[6] in 1908, as well as others since then, noted that under most conditions the amount of protein digested at a given concentration of pepsin preparation could be fairly well expressed as being proportional to the square root of the time, for about the first 50 per cent. of the hydrolysis.

The course of the action may then be expressed at two levels of enzyme concentration, A and B, in terms of reaction constants, as follows:

$$k_A = \frac{1}{t} \cdot x^2$$

and

$$k_B = \frac{1}{t} \cdot x^2$$

where x is the amount of protein digested at time t. The ratio of the reaction constants is, for a given value of t as, for example, 16 hours in the experiments of E. Schütz,

$$\frac{k_A}{k_B} = \frac{x^2_A}{x^2_B}.$$

In other words, as the enzyme concentration is varied, the ratios of the reaction constants, which are a proper measure of the velocity of the reaction, are equal not to the ratios of the amounts changed in a given time, but to the ratios of the squares of these amounts. According to E. Schütz's own data, the amounts changed in a given time are proportional to the square root of the enzyme concentration,

$$\frac{x_A}{x_B} = \frac{\sqrt{E_A}}{\sqrt{E_B}},$$

or

$$\frac{x^2_A}{x^2_B} = \frac{E_A}{E_B}.$$

Since, as shown above,

$$\frac{x^2_A}{x^2_B} = \frac{k_A}{k_B},$$

then

$$\frac{k_A}{k_B} = \frac{E_A}{E_B},$$

or the reaction velocity is directly proportional to the concentration of enzyme, not to the square root thereof.

When the reciprocal of the time required to reach a given stage in the enzymic reaction is used as a measure of reaction velocity (and this is a more proper measure than the amount changed in a given time, although it also has limitations) there may be instances in which the Schütz-Borissov law seems to be approximated or even followed. But such simulation appears to be due, at high concentrations of enzyme, to the presence, as impurities in the enzyme preparation, of proteolytic products which apparently combine with the enzyme to form enzymically inactive compounds.[7,8]

There would appear to exist, therefore, no substantial data to contravene the general rule that the velocity of reaction is directly proportional to the concentration of enzyme, within rather wide range of the latter. Data indicating such contravention must be evaluated with respect to (a) the measure of reaction velocity used and (b) the possible presence of accompanying substances, impurities or reaction products which affect the activity differently at different enzyme concentrations.

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[3] E. Schütz, *Zeits. physiol. Chem.*, 9: 577, 1885.

[4] Borissov, Inaugural Dissertation, St. Petersburg, 1891, quoted by J. Schütz.

[5] J. Schütz, *Zeits. physiol. Chem.*, 30: 1, 1900.

[6] S. Arrhenius, *Medd. Kong. Vetsakad. Nobelinst.*, 1908, 1.

[7] J. Northrop, *Jour. Gen. Physiol.*, 2: 471, 1920.

[8] O. Bodansky, *Jour. Biol. Chem.*, 114: 273, 115: 101, 1936.

RELIC FLORA IN RELATION TO GLACIATION IN THE KEWEENAW PENINSULA OF MICHIGAN

IN a paper entitled "Critical Plants of the Upper Great Lakes Region of Ontario and Michigan," which

appeared in Vol. 37 of *Rhodora* for 1935, Dr. M. L. Fernald has introduced an attempt to substantiate a view that certain portions of the Keweenaw peninsula of northern Michigan escaped glaciation during the Wisconsin stage of the Pleistocene. His contentions are based essentially upon botanical evidence as related to the existence there of "a great assemblage of remotely isolated relic species and isolated endemics" (p. 205), representatives of which are found only in areas widely removed from this center. The criteria which he employs in an effort to discount the possibilities of a Wisconsin invasion of the ice sheet in the region of "West Bluff" (p. 204), for instance, are wholly inadequate to prove his contention. The glacial facts at hand were either grossly overlooked or deemed too unimportant to be given consideration in the problem. With these points in mind the writer made a special trip into the Keweenaw peninsula for the purpose of ascertaining the status of the area in so far as geological evidences for glaciation are concerned. On the basis of this field investigation, I am compelled to take issue with Dr. Fernald in his hypothesis for a "driftless" condition in the Keweenaw region. The evidences for glaciation, even in the higher levels of the bluffs, are so obvious that it is difficult to understand how they could have been missed by him. If Dr. Fernald had taken pains to carefully scrutinize the composition of the terrane in the north slope of West Bluff, he would undoubtedly have noted that the rock pavement is mantled to the very summit with a thin veneer of glacial till. The drift cover of boulder clay contains numerous erratics such as granite, diabase, diorite and greenstone; rocks which are foreign to the local area.

In a recently opened road cut about 140 feet southeast of the U. S. Geological Survey bench mark, which marks the highest point of the bluff, the glacial drift had been scraped off to expose a narrow strip of bed rock for a distance of 50 or 60 feet. The conglomerate, which forms the pavement over which the ice sheet moved, carries numerous glacial striae and scratches which bear generally S.80°W. So powerful was the attack of the ice in the area that the striated cobbles and pebbles which comprise the conglomerate were planed off sharply. The striations and scratches on bed rock were traceable to within five feet of the summit level of the bluff. From this elevation to the crest, the rock pavement is masked by a mantle of boulder clay which was left by the wasting ice in its retreat. Glacial evidences in the form of bouldery till, striations on rock floor and ice-planed cobbles within the pavement conglomerate certainly can not be utterly disregarded, in consideration of the problem concerning glaciation. On page 204 of his paper, Dr. Fernald refers to the "rotted" condition of the material comprising "West Bluff" and seems to make quite an issue of the fact that the atmosphere was filled with "clouds of wind-blown sand and dust of purely local origin." That the material is of local origin is not demonstrated and, so far as I can reason, there is no particular point in emphasizing facts concerning aeolian translocation in the light of attempting to prove either the presence or absence of glacial deposits in a given locality.

On page 205, Fernald states that his interpretation is supported by botanical evidence:

> Keweenaw County has a greater assemblage of remotely isolated relic-species and isolated endemics than any other botanically explored region between Gaspe Cliffs and mountains and the Driftless Area of Wisconsin, Minnesota, Iowa and Illinois.

It is not my purpose to attempt to discredit Dr. Fernald's observations that the Keweenaw peninsula harbors a wide floral range whose counterparts on the continent are widely separated. I am thoroughly convinced, however, that criteria other than those set forth by him are necessary to clarify the problems related to the concentration of so-called relic-species in this locality. He then indicates the need for checking geological interpretations elsewhere on botanical evidence.

On page 217 of his report we find the following statements:

> These observations on the Keweenaw Peninsula inevitably suggest that similar conditions will be found in other sections of the Upper Great Lakes area, especially where elevated and vertical escarpments and sharp bluffs stand high above the general level. So long as the botanist meekly accepts, without personally checking, the proposition that all the Upper Great Lakes region was completely under Wisconsin ice (and to a depth sometimes said to be 2000 feet) and then under the water of the Lakes he will fail to solve this striking phytogeographic problem. If he will visit the high bluffs and escarpments and himself *see* the conditions, he is likely to find that the bluffs of Keweenaw are not alone in lacking the abundant transported drift with which orthodox geology has blanketed them. He is likely to find that their crests and slopes have, instead, a rotted and angular crust or deeply weathered mantle in situ. It will then be demonstrated that there were in the Upper Great Lakes region *several driftless areas,* limited in extent but sufficient to have maintained colonies of the formerly wide-spread and somewhat generalized Tertiary flora, species which, in areas of active Wisconsin glaciation, were eliminated in favor of the younger and more aggressive series of plants.

I fear such checking elsewhere might have no better basis than on the Keweenaw peninsula. During the maximum extension of the Superior lobe, the Keweenaw and Chippewa tongues of ice became confluent upon the Keweenaw Peninsula and covered it com-

pletely. The ice of the Chippewa lobe extended to the southwestward for a distance of 150 miles beyond the Keweenaw Peninsula, and terminated there at an altitude some 300 feet above the level of West Bluff. It over-rode the Porcupine Mountains and other land areas near the Wisconsin line, where the relief is 500 and more feet higher than at West Bluff. To do this it must have been 1,000 feet or more above West Bluff for the surface of the ice sheet slopes downward toward its border.

If, as Fernald claims, the "relic-species" found in the Keweenaw Peninsula are hold-overs of a "formerly wide-spread and somewhat generalized Tertiary flora" (p. 217), then it is necessary to assume that the species in question not only survived the Wisconsin stage of glaciation but likewise the much longer and more wide-spread Illinoian stage as well. It is difficult for the glacialist to understand how the botanist gets his "relic flora" through an interval of 150,000 to 200,000 years of ice refrigeration, as represented by the Wisconsin and Illinoian stages, to say nothing of the much more protracted pre-Illinoian time, in the transition from the Tertiary to the present. Certainly the interval involving the wide-spread activities of pre-Wisconsin glaciation can not be neglected in the proper interpretation of the problem.

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"MIGRATION" AND "HOMING" OF PACIFIC SALMON[1]

IN a recent issue of SCIENCE[2] Professor A. G. Huntsman stated that he was unable to find a single clear case of a salmon returning to its natal stream from a place in the sea away from the area influenced by the fresh water of its natal stream. He also assumed that salmon, when wandering in the sea beyond the gradient produced by their natal streams, become lost and may reach neighboring streams or travel farther to sea. Since Professor Huntsman has included the Pacific salmon of the genus Oncorhynchus in his category I would like to give evidence which shows that these salmon migrate to sea far beyond the influence of the gradients produced by their parent streams, mature and then return to their parent streams to spawn.

The Fraser River and its tributaries in British Columbia form one of the largest river systems on the Pacific coast of North America. This river system is noted for its high production of sockeye salmon (*O. nerka*) which form over 90 per cent. of the commercial catches of sockeyes in the Swiftsure Bank-Puget Sound-Fraser River region.[3] There are also a number of other streams of considerable size in this region, but only a few of them support populations of sockeye salmon, which in all form only a small fraction of the populations of the Fraser River system.

The majority of the Fraser River sockeyes migrate to and from the sea through the channels immediate to the river's mouth and the adjoining channel of the Strait of Juan de Fuca. The fresh waters of the Fraser River as well as those of all the streams in the Puget Sound area flow seaward through the Strait of Juan de Fuca. Since there are rapid tide movements in this strait these fresh waters become mixed shortly after they enter the strait. There is also a rapid mixing of the fresh waters with the salt water throughout the course of the strait so that no definite gradient is maintained. Hence if all the Fraser River sockeyes had to mature within an area in the sea influenced solely by the river's water or else become lost, they would all have to mature within the channels immediately adjoining the river's mouth. During the many years the salmon fisheries have been carried on in these channels as well as in the Strait of Juan de Fuca there is no record of the catch of partially mature sockeyes in these waters at any time in the year. In the years when salmon traps were operated in this region they were set weeks before the beginning of the spawning migration and yet no catches of partially mature sockeyes or adults were ever made at this time. In fact no adult salmon are ever caught within these waters except during the season of the spawning migration, which extends from May to October. During this period they are caught in the open sea on Swiftsure Bank as well as in the Strait of Juan de Fuca and the adjoining channels through which they migrate to the Fraser River.[4] This is certainly sufficient evidence to show that the adult sockeyes which return to the river to spawn each season mature within the open sea far beyond the gradient produced by the fresh waters of the river.

Evidence which shows that the adult sockeyes which migrate into the Fraser River are native to it may be found in the studies of Dr. R. E. Foerster at Cultus Lake, British Columbia.[5] This lake forms the headwaters of a tributary to the Fraser River. Thousands of young sockeye salmon from Cultus Lake have been marked by removing two or more of their fins. The adult salmon bearing these marks have been recovered by the fishery on Swiftsure Bank in the open sea, in the Strait of Juan de Fuca, in the waters in the immediate vicinity of the mouth of the Fraser River and in the river. Large numbers of adults bearing the marks have also been recovered at Cultus Lake. The

[1] Published by permission of the U. S. Commissioner of Fisheries.

[2] SCIENCE, 85: 313–314, 1937.

[3] A complete description of this region and the commercial salmon fisheries it supports is given by G. A. Rounsefell and G. B. Kelez, Special Rept. U. S. Bureau of Fisheries, 1935.

[4] See H. O'Malley and W. H. Rich, Rept. U. S. Comm. of Fish., 1918, app. viii, 38 p.

[5] R. E. Foerster, *Jour. Biol. Board Canada*, 3: 36, 1936.

first marked salmon that have been recovered each season have been caught on Swiftsure Bank and in the region of the Strait of Juan de Fuca. Therefore, these results, together with those of the commercial fishery, show that the adult sockeye salmon migrating into the Fraser River each season are native to it and come from the open sea, where they have matured.

Mr. G. B. Kelez in his studies of the coho salmon (*O. kisutch*) of the Puget Sound region has found a similar relationship in the commercial catches of these salmon, and from his marking experiments, data unpublished, has found that they are native to the streams of the region.

Another good example of the migrations and homing of the Pacific salmon may be found in the studies of the pink salmon (*O. gorbuscha*) of southeastern Alaska. This part of the territory is composed, for the most part, of a group of large islands known as the Alexander Archipelago. There are over 900 streams in this region, which range in size from mere trickling creeks to large rivers. Practically all these streams support populations of pink salmon. Many are only a few hundred feet apart at their mouths and flow into bays. Others are more or less isolated along the shores of inlets. As many as 25,000 pink salmon may be found spawning each year in creeks not more than a few yards in width and a half mile in length. The areas in the bays and inlets influenced by the fresh waters of these streams are so small that it would be impossible for more than a few salmon to mature within them, let alone thousands of fish. Furthermore, no half-grown pink salmon have ever been found within the inside waters among the islands throughout the entire region. Nor are any adult pink salmon found within these waters except during the season of the spawning migration, which extends from June to October.

Salmon traps are operated by the commercial fishery along the shores of the main channels of entry into the inside waters among the islands. Since these traps are stationary units of gear, the time of appearance of the salmon runs in the channels may be determined readily from the time in the season the trap catches are made. Records of the daily catches of these traps have been collected for a period of 20 years. There has never been a year when some of these traps were not set prior to the beginning of the salmon runs. The first traps to catch pink salmon each season have been invariably those located near the entrances of the channels into which the salmon migrate from the open sea. Observations in the offshore waters shortly before the pink salmon begin their migrations into the channels have revealed the presence of these fish in large schools milling about but gradually moving towards the shore.

That these pink salmon return to their parent streams in southeastern Alaska is also not a matter of conjecture. In the spring of 1931 I marked 50,000 pink salmon fry by removing two of their fins at a small stream flowing into Olive Cove on Etolin Island.[6] This stream is more or less isolated from other pink salmon streams in the district. The adult salmon bearing the marks returned to Olive Cove in the summer of 1932. At this time a search was made in all the neighboring streams for marked salmon, but none were found. This would indicate that there is a high degree of homing in the pink salmon. However, I have not assumed that this would be true of all streams, for from my studies of the return of marked pink salmon to the Duckabush River on Hood Canal, Washington, I found there was a certain degree of straying from the parent stream.[6] The Duckabush River is located on the canal between and within a few miles of two other streams of similar size. Marked adult pink salmon were found in both of the neighboring rivers, but the great majority of the returns were to the parent stream. Hence it is not improbable that the pink salmon populations in streams more or less isolated from other streams may show little tendency toward straying, whereas populations in streams in the vicinity of other streams may show some degree of straying into the neighboring streams. Furthermore, I am not aware of any biologists at the present time thoroughly familiar with the life histories of the Pacific salmon who are of the opinion that any of the species return to their parent streams with unerring accuracy. The studies of Dr. A. L. Pritchard on the homing of the pink salmon[7] as well as my own studies indicate that the homing of these salmon is of a sufficient degree to justify conservation measures on the basis of the parent stream principle.

The practical application of this principle in the conservation of all the species of Pacific salmon has given most satisfactory results. The U. S. Bureau of Fisheries has records to show that the protection of the salmon populations in individual streams has brought about a great increase in their abundance and that when this protection is removed the populations again decline in abundance. In view of the evidence both from the practical as well as the scientific standpoints the Bureau of Fisheries is firm in its conviction that this principle is sound both in theory and practice.

FREDERICK A. DAVIDSON
U. S. BUREAU OF FISHERIES

CANNIBALISM AND PRIMITIVE MAN

QUALITIES are often attributed to fossil men which, upon the evidence offered, would in any Primate court of justice be considered actionable. It is time that a

[6] See F. A. Davidson, *Bull.* U. S. Bur. Fish., 48: 15, 1934.

[7] A. L. Pritchard, Ann. Rept. Biol. Bd. Canada, 1933.

protest were entered against a practice which is altogether indefensible, more particularly since those to whom such qualities are attributed are unable to defend themselves.

When the charred remains of human bones are found on some Pleistocene hearth it is generally at once assumed that those who were responsible for their condition were cannibals. Is such a find evidence of cannibalism? Possibly not. But when it is added that the bones so found are cracked in such a manner as to indicate that the marrow was extracted by some human agency, who can deny that these fossil humans must have been cannibals? I submit that denial or affirmation is here a matter of scientific impossibility, but I would also point out that under conditions of scarcity modern primitive peoples, who by any standard could hardly be called cannibals, have been known to kill their young and feed them to those who were left. Is it not also true that under similar conditions highly civilized men have been known to do the same? And are they therefore to be characterized as cannibals? The point need not, I think, be pressed. The consumption for occasional ritual purposes of certain parts of the human body is a practice which is to be found among many primitive peoples to-day, but no people of whom we have any knowledge makes a habit of cannibalism. In fact, cannibalism is a pure traveler's myth.

My friend, Dr. G. H. R. von Koenigswald, has recently endowed the fossil Pleistocene men of East Java discovered by him with the quality of being brain-eaters. The evidence for this he finds in the fact that in each of these skulls the facial bones were completely broken away by some human agency. He assumes, therefore, that the human agents were desirous of securing the brain for gastronomical purposes. This is certainly a possible inference, but is it a probable one?

Reading recently in Herbert Basedow's delightful "The Australian Aboriginal" (Adelaide, 1929, p. 95), I came across the following paragraph:

"The Narrinyerri and other tribes south of Adelaide used human calvaria as drinking vessels. *The facial skeleton of a complete skull was broken away so as only to leave the brain-box; and this held the water.*" (Italics mine).

I leave the eduction of the proper relation to others.

Java is, of course, very near Australia. Let the ethnologist who will, swoop with delight at what he may take to be the persistence of a culture-trait in Australia of to-day which was already in existence in Pleistocene Java. Or shall we say that we have here a case of independent invention? The physical anthropologist will place a finger upon his *alar nasi* and point to the Australoid characters of the Javanese fossil crania. The reader may remark, "How interesting."

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SCIENTIFIC BOOKS

ELECTRICITY

Electricity. By W. L. BRAGG. The Macmillan Company. 1936.

THE first thing to make clear about this book is that its author is not W. H. Bragg, whose reputation for excellent exposition is already world-wide, but W. L. Bragg, his son, whose writings thus far have consisted largely of treatises and of accounts of his own researches and those of his school in the field of crystal analysis by means of x-rays. (No physicist needs to be told that in this field he was one of the pioneers and to this day an outstanding figure.) Had I been prompter in writing this review, I should have described him as professor in Manchester University; now I can add that he is the new director of the National Physical Laboratory.

The book originated from a course of six lectures "adapted to a juvenile auditory" at the Royal Institution, and consists of six chapters entitled: What is Electricity?, How Electricity Travels, Motors and Dynamos, Our Electrical Supply, Telegraphs and Telephones, Oscillating Electrical Circuits [mostly wireless]. The juvenile auditory is exhibited in the frontispiece, and as one reads along in the book one comes to comprehend the expression of intent concentration which their faces wear: it must have been a wonderful experience to be able to watch, while hearing Bragg's exposition, the actual demonstrations which here must be translated into words. I must add that the translation is often well done, some of the experiments being described so plainly that one is tempted to follow the author's advice and try them for one's self.

The book is far from being an account of electron-theory; electricity is introduced by describing the ancient and the classical experiments up to and through the time of Faraday, and electrons and atom-models are described in hardly more than a casual fashion, just before the author enters upon the description of electrical apparatus. I find it strange to see lines of force so emphasized, even to the extent of explaining the spreading of charge over a conductor as due to the repulsion, not of the elementary charges but of the lines of force for one another. Millikan's method of measuring the electron-charge is mentioned (though with the unfortunate implication that the oil-drop

picks up free electrons only) but not the value of the electron-charge nor any way of measuring the electron-mass—unless I have carelessly overlooked something. The electron thus remains rather vague, and little is said about the atom-model, except for one brilliant simile which affords a welcome relief from the sun-and-planet's image: Bragg compares the model with "someone's head with a cloud of mosquitoes around it."

The chapters on motors, dynamos and electrical supply are interesting, informative and not always easy. We learn from the preface that "I have tried to judge how deeply I might go into the various subjects by remembering the questions I was asked after the lectures. If parts of this book seem unduly difficult, it is because these questions gave me so high an opinion of the intelligence of the rising generation." This being the case, I should think that mathematical formulae need not have been entirely avoided. If, however, formulae must be avoided, I doubt whether alternating-current phenomena can be better treated than they are in Bragg's book. The descriptions of such types of apparatus as the dynamo, the alternating current meter and the Creed teleprinter are well done. I hope, however, that the rising generation does better by the interpretation of contact potential difference than I have. I do not venture to comment on the chapters on telephony and radio, lest my comments be thought to be based on fuller knowledge than I possess.

The illustrations, both sketches and photographs, are numerous and excellent. The book is well printed and pleasant to read. Misprints are remarkably scarce, and the only confusing passage I have found is that on page 143, where "sheet" is used to designate sometimes one and sometimes the other of two electrodes. The style is conversational, not to say chatty, and now and then delightfully jocular. "Why do electrons [enable metals to reflect light]? Because they are electrified particles and react to light according to certain laws. Why do electrified particles obey these laws? At this stage we are reduced to saying in an exasperated way: *Because they jolly well do.*" "... Our description of the flow of current is just the opposite to the actual flow of electrons. Perhaps the following analogy will clear up the puzzle. Suppose I take the spare cash in my pocket and hand it over to you. Ought I to say that a current of riches has passed from me to you, or that a current of poverty has passed from you to me? (Unfortunately in the case of the electric current it was as if everyone agreed to say the current of poverty passed from you to me.)" "When we remark 'It wasn't what he said but the nasty way he said it,' we are unconsciously distinguishing speech on the one hand from the larynx noise on the other hand, which latter is largely responsible for conveying emotion apart from words."

KARL K. DARROW

BELL TELEPHONE LABORATORIES
NEW YORK

SOCIETIES AND MEETINGS

ACTIVITIES OF THE PHOENIX LOCAL BRANCH OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE Phoenix Local Branch brought to a close its third year of activities on the fifteenth of April, with its twentieth lecture of the season.

A meeting of the board of councilors was held on September 20, at the Arizona Museum. The nominating committee presented its list of candidates, and ballots were sent out accordingly. The officers elected for the ensuing year were: A. L. Flagg, *President;* Dr. John A. Lentz, *Vice-president;* with Professor J. W. Hoover, Claude E. McLean, J. E. Thompson and Odd S. Halseth as members of the board to serve for four years.

The branch was without a secretary nearly the entire year, as Mr. Halseth, the second secretary, resigned at the September board meeting. The board has recently prevailed upon Mr. Alfred E. Knight, a past president of the American Institute of Science of New York City, to act as secretary-treasurer. Mr. Knight brings to the Phoenix Branch his wide experience in doing successfully the things we hope to do in Phoenix. We are very fortunate to have him cooperate with us.

The series of lectures sponsored by the Phoenix Local Branch during the season just closed was well received. The total attendance at twenty lectures amounted to 1,194. A wide range of subjects was covered: Archeology, astronomy, chemistry, geology, geography, mineralogy, ornithology, physics, plant pathology and zoology. Some lectures were illustrated. The attendance of students from the high school and junior college should be mentioned, for it is from these sources that the future workers in the fields of science must come. The interest shown in the whole lecture series indicates clearly that there is a demand for such programs and the active members feel encouraged to continue this work.

Qualified speakers are within reach. Our experience has shown that appreciative audiences will attend scientific lectures if proper publicity is given. Therefore, we look forward to a better ordered and more successful year of service to the community during the season 1937–1938.

A. L. FLAGG,
President, Phoenix Local Branch

SPECIAL ARTICLES

THE EFFECT OF THE REPLACEMENT OF OTHER CATIONS BY SODIUM ON THE DISPERSION OF SOILS

THE effect on physical properties of soils by the replacement of other cations by sodium in the base exchange complex of soils has been the subject of much study by soils investigators. It was the subject of a report[1] of one of the Committees of the Section of Hydraulics of the American Geophysical Union in 1936. The summary of the report states in part: "Laboratory experiments in general show that such physical measurements as moisture-equivalent, permeability, deflocculation, absorption of water-vapor, heat of wetting, density during drying, hardness of crumbs of the dried soil and cohesiveness are all increased by the substitution of sodium- or potassium-ions in the exchange-complex and are decreased by the substitution of calcium or hydrogen."

A number of soils investigators have reported that treatment of soils with sodium salts and subsequent leaching results in dispersion of the soil colloids and in an increase in the water-holding capacity of the soil. The moisture equivalent of the soil usually is taken as a measure of its water-holding capacity. The moisture equivalent has been reported to be correlated with other physical properties of the soil. In connection with studies on the effect of organic matter and other fertilizers on some of the water relations of soils, the writers have had occasion to make a number of moisture equivalent determinations on salt-treated soils. The results of these tests show that neither the treatment with sodium salts nor subsequent leaching of the salt-treated soils with distilled water materially affects the moisture equivalent.

The results of some of the tests are shown in the accompanying table. Three California soils were tested, Yolo clay, Farwell loam and Aiken loam; and

TABLE I

MOISTURE EQUIVALENTS OF SALT-TREATED AND UNTREATED SOILS

Soil	Natural untreated soil	Natural soil mechanically stirred	Soil treated with 1 N NaCl sol. and leached with distilled water	Soil treated with 1 N NaCl sol. and leached with distilled water, mechanically stirred
Yolo clay .	27.2 ± .04	28.4 ± .07	28.1 ± .05	28.6 ± .02
Wooster silt loam.	20.3 ± .04	22.3 ± .05	20.4 ± .04	22.1 ± .04
Aiken loam	32.6 ± .05	33.7 ± .06	33.1 ± .05	33.8 ± .05
Farwell loam	24.8 ± .03	26.7 ± .04	25.8 ± .03	26.5 ± .05

a Wooster silt loam from Wooster, Ohio. All these soils except the Aiken loam, a red lateritic soil, have relatively large base-holding capacities. For example, the Yolo clay has a total of 27.3 milligram-equivalents per 100 grams of soil. These soils were treated with $NaNO_3$, NaCl and Na_2SO_4, but only the results with the chloride are reported, since the other salts gave similar results.

Enough of each sample was placed in a standard centrifuge cup to give a 30-gram sample of water-free soil.[2] The salt-treated samples were soaked in one normal salt solution for a period of about 12 hours. The soil was then drained and the samples washed with fresh solutions and then leached five times with distilled water while in the centrifuge cups. This treatment in the case of Yolo clay raised the sodium in the base exchange complex from 4.4 to 12.1 milligram-equivalents per 100 grams of soil; and in the case of the Wooster silt loam the soil was about 65 per cent. saturated with sodium. Some of the samples were also stirred with a glass rod just before placing them in the centrifuge. This stirring, however, did not equal the mechanical manipulation the soil would receive if it were transferred from a leaching funnel to the cups, as probably was done in previous work of this kind. Samples without salt treatment and leaching were also prepared, and some of these were mechanically stirred in the same manner as the salt-treated samples. Sixteen samples for each treatment were run in separate centrifuge sets of four each.

The salt-treated leached samples have slightly higher moisture equivalents than the untreated samples, but the differences are much less than reports of previous work suggest,[3] and the difference is not significant in the case of the Wooster silt loam. Mechanical agitation of the untreated soils in every case increased the moisture equivalent more than the salt treatment did.

The very large increases in moisture equivalent which are thought to result from the dispersions due to the replacement by sodium may simply be due to the technique used, since the moisture equivalent may be materially affected by a number of factors.[4] In our tests we attempted to keep the procedure in making the determinations of the salt-treated and check samples as nearly identical as possible.

That mechanical agitation markedly increases the moisture equivalent is shown in tests with the Aiken loam by running the samples in an unbalanced centrifuge load. The moisture equivalent of the soil was raised from 32.6 to 40.1. We have encountered some

[1] F. J. Veihmeyer, *Transactions American Geophysical Union*, seventeenth annual meeting, Part 2: 318–326, 1936.

[2] F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad, California Agr. Exp. Sta. Technical Paper 16: 1–65, 1924.

[3] L. T. Sharp and D. D. Waynick, *Soil Sci.*, 4: 463–469, 1917.

[4] F. J. Veihmeyer, J. Oserkowsky and K. B. Tester, Proc. and Papers, First International Cong. Soil Sci. (Washington, 1927) 1: 512–534, 1928.

soils, not given in the table, which become so dense during the centrifuging process that water will not pass through them. In some cases this condition has resulted when the centrifuge is brought up to speed too quickly, the soil becoming so compact water will not pass through it. This impervious condition has also been found when some of the soils were mechanically stirred in the centrifuge cups just before placing the samples in the centrifuge. In fact, in many cases standing water was found on the surface of the sample after centrifuging. We believe that under such conditions the moisture equivalent is meaningless. The results simply indicate that the soil was rendered impervious and the results obtained bear no relation to the textural properties of the sample.

The conclusion from our work with salt-treated samples is that more dispersion can be brought about by mechanical agitation than by salt treatment and leaching. These results indicate that the impervious conditions sometimes observed in the field, where the soil was pervious formerly, and attributed to the dispersion resulting from irrigation with salty water, may be brought about by mechanical working of the soil when too wet.

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PIGMENTATION IN THE ROOT OF THE COTTON PLANT

IN connection with investigations of the effect of fertilizers on the incidence of cotton root rot (*Phymatotrichum omnivorum*) repeated observations have been made of consistent relationships between the pigmentation of cotton roots and stage of plant development, soil characteristics and fertilizer treatment. In field experiments on Wilson clay loam, a non-calcareous soil of the Blackland prairie section of Texas, fertilizer treatments in which phosphoric acid dominated tended to accelerate the appearance of root rot, as evidenced by above-ground symptoms, while fertilizers in which nitrogen dominated produced a converse effect. These same fertilizers had, respectively, the effect of hastening or retarding the physiological age of the cotton plant. Associated with these effects there was also observed a gradation in the pigmentation of the root bark; in mid-summer the roots of plants from unfertilized plats were a pale yellow, those from plats treated with high-nitrogen fertilizers were of a lighter tint, while high-phosphate plants displayed a distinctly reddish shade. Later in the season, the unfertilized and high-nitrogen plant roots acquired this reddish cast, while that of the phosphate-fed roots was intensified, consequently the gradient of color was maintained until all plants were matured.

The roots of cotton seedlings grown on the calcareous soils of the blackland section are also pale yellow; the red pigmentation appears about the time that the first squares are set, and becomes more intense as the season advances, so that at the end of the season the roots exhibit a deep red coloration, regardless of fertilizer treatment. The Wilson soils have a lower pH value than those of the Houston series. Limited observations of cotton plants of comparable age grown on the acid soils of east Texas indicate that this red pigment does not appear until later in the development of the plant, and at maturity the intensity of the color does not approximate that of plants produced on the less acid to alkaline soils of the blackland section. Thus it appears that the reaction of the soil, physiological age of the plant and fertilizer treatment are factors in the pigmentation of the roots of cotton plants grown in this region.

A systematic study of the pigmentation of the cotton root was begun in 1935 and continued during 1936, on samples taken periodically throughout the growing season. Roots, as prepared for carbohydrate studies, were extracted with boiling alcohol whose final strength after contact with the plant material was not less than 80 per cent. In 1936, the plants were divided into two parts, namely, bark and woody tissues. The alcoholic extracts of the woody part were yellow; these changed to orange toward the end of the season. Those of the bark were yellow until the stage of square formation at which time the red coloration appeared, and this latter color became more intense as the season advanced. The bark extracts, even though they were intensely red, were found to contain some of the yellow. The variations in the reddish color of the bark which are discernible to the eye before heating with alcohol, are intensified in the alcoholic extract; the extracted bark-tissue is also much more highly colored than the unextracted.

Comparisons were made of extracts from roots of plants grown on Wilson clay loam with 0-15-0,[1] 3-9-3, 9-3-3 and 15-0-0 fertilizers; an unfertilized check plat was also used. The volumes of the extracts were adjusted so that the same ratio of liquid to plant material was maintained. Using the plant grown on the 0-15-0 fertilizer plat as a standard, the relative color intensity of the extracts from the other treatments were determined with facility by the use of the colorimeter. The intensities of the red pigment of the bark of plants produced with the 0-15-0 and 3-9-3 fertilizers were greater than that of the check, while those of the 9-3-3 and 15-0-0 samples were less; the extremes were produced by the 0-15-0 and 15-0-0 fertilizers. These differences were obliterated late in the season.

Wayne,[2] Drueding[3] and Power and Browning[4] have

[1] N–P_2O_5–K_2O.

[2] E. S. Wayne, *The Pharmaceutical Journal and Transactions*, 3: 64–65, 1872.

reported a red to purple material as a component of the root of the cotton plant; the color here described is apparently related to this material. Drueding also reported a yellow material obtained from the bark of the root. Although none of the workers established the identity of the red material, Wayne called it *Gossypic* acid due to its acidic nature. The red-purple pigment has been obtained in this laboratory by precipitation from the alcoholic extract of mature cotton plants with an excess of 10 per cent. sodium hydroxide, washing with slightly alkaline 80 per cent. alcohol, dissolving in water, and precipitating with hydrochloric acid; this gelatinous material was then washed with water. It dries to an amorphous powder of a red-purple color. When dissolved in 80 per cent. alcohol, it responds to the qualitative tests of the anthocyanins as given by Onslow.[5]

Although the yellow to orange material of the alcoholic extracts of the woody tissue of the root is less susceptible to isolation, qualitative tests applied to these extracts indicate the presence of a pigment which displays characteristics of the flavone and flavonol pigments. Early in the season the high-nitrogen fertilizers produced a higher concentration of the yellow than the high-phosphate, but as the season advanced the highest concentrations of the yellow of the woody tissue and the red of the bark were both produced by the same fertilizer treatment.

There has been observed a general correlation of the pigmentation of the cotton root with the physiological age of the plant, the reaction of the soil, the effect of fertilizers and the incidence of cotton root rot as observed in the field.

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THE DORSOVENTRAL AXIS OF THE FORELIMB BUD IN AMBLYSTOMA MICROSTOMUM

THE following experiments were performed to determine the stage of development at which the dorsoventral axis of the forelimb bud of *Amblystoma microstomum* is established. It has been known since Harrison's studies[1] that the dorsoventral axis of a limb may not be determined until much later than the anteroposterior axis. Swett[2] showed that in *A. punctatum* the former axis in the forelimb bud is not irreversibly established until stage 35 (Harrison's stages), whereas in *A. tigrinum* Hollinshead,[3] using grafts only two somites in diameter, found that it is not until stage 38 that all grafts retain their prospective asymmetry.

The forelimb bud of *A. microstomum* is first visible externally as a rounded elevation beneath somites 3, 4 and 5 at stages 35 to 36. Round disks of tissue 3 to 3½ somites in diameter were removed from this region at stages varying from 27 to 34. In order to reverse only one axis, left limb buds were transplanted to the right flank in a location midway between the fore and hind limbs. This orientation resulted in an inversion of the dorsoventral axis, while retaining for the anteroposterior axis a normal relationship.

In all, 104 operations were performed, but in 30 cases the host died. In those surviving, 9 grafts were resorbed and 25 produced limbs which were too imperfect to be interpreted. The remaining 40 cases formed supernumerary limbs: 17 with the asymmetry reversed and 23 were inverted left limbs with asymmetry not reversed.

Of the eleven positive cases operated on at stages 27 to 31, ten had reorganized the dorsoventral axis and formed right limbs (Table 1). The eleventh case, performed at stage 29, formed a double limb, the primary member of which was an inverted left limb. It is believed that either this case was an error or that the transplant was larger than 3½ somites. No inverted limbs were obtained in the seven positive cases transplanted at stages 30 and 31.

TABLE 1
SHOWING THE DETERMINATION OF THE DORSOVENTRAL AXIS IN AMBLYSTOMA MICROSTOMUM

Stage	Total	Harmonic right	Inverted left
27–29	4	3	1
30	2	2	0
31	5	5	0
32	12	7	5
33	9	0	9
34	7	0	7
Totals	**39**	**17**	**22**

Stage 32 proved to be the transitional stage. In about half of these cases there developed right limbs and in the other half, inverted left limbs. This variation may be explained on the basis of slight differences in the size of the graft or in the age of the donor.

At stage 33 there were nine grafts which developed limbs and all nine had retained their prospective asymmetry. The dorsoventral axis had been established at the time of the operation and had continued its devel-

[1] R. G. Harrison, *Jour. Exp. Zool.*, 32: 1–136, 1921.
[2] F. H. Swett, *Jour. Exp. Zool.*, 47: 385–439, 1927.
[3] W. H. Hollinshead, *Jour. Exp. Zool.*, 73: 183–194, 1936.
[3] C. C. Drueding, *ibid.*, 8: 245–246, 1877.
[4] F. B. Power and H. Browning, *The Pharmaceutical Journal and Pharmacist*, 93: 420–423, 1914.
[5] "The Anthocyanin Pigments of Plants," 2nd edition, 1925, Chapter 4, by M. W. Onslow.

opment according to its original orientation. Digits 3 and 4 were formed on the ventral border, indicating that this was the ulnar side, and as development progressed the palm of the graft turned dorsally.

Similar results were obtained at stage 34. In all positive cases the formation of the hand indicated that the asymmetry had not been reversed.

Several limbs transplanted at stages 33 and 34 have been sectioned. The asymmetry of the pectoral girdle was reversed; a harmonic right girdle had developed from a left limb rudiment. The supernumerary appendage was an inverted left limb with a normally oriented right girdle.

We conclude that the dorsoventral axis of the forelimb bud of *A. microstomum* is determined in a manner similar to that of other species of the genus which have been studied. The dorsoventral axis for 3 somite grafts is partially determined at stage 32 and becomes firmly established at stage 33. These experiments are being continued.

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THE RETICULO-ENDOTHELIAL SYSTEM AND THE CONCEPT OF THE "ANTI-HORMONE"[1]

NUMEROUS investigations have shown that, following prolonged administration of certain endocrine preparations, loss of sensitivity to the injected extract will eventually result. Collip and his associates believe that normally hormonal effects are kept in balance by the presence of specific anti-hormones and that these appear in excess when animals are chronically treated with various endocrine extracts. Another group claims that this response is of immunity reaction nature and believes that the inhibitory substances are antibodies. One way of determining which of the two interpretations is correct would be to administer such hormone preparations to animals from which a large portion of the reticulo-endothelial system, intimately concerned with antibody formation, has been removed. Since the spleen is the most concentrated source of reticulo-endothelial tissue in the body and since the ratio of its weight to body weight is relatively great in the rat, we have compared, in our first studies, the response of young immature splenectomized and normal hooded litter mate female rats to daily injections of 10 R.U. pregnancy urine extract (Follutein or Antuitrin S).

In the controls, the ovary size reaches a maximum after approximately 10 to 15 days of treatment and then regresses, becoming normal in size within two to three months, despite continued injection. The ovaries of the splenectomized rats, however, continue to grow, attaining weights approximately 2 to 3½ times that of the injected controls, 20 to 30 days after splenectomy. This increase in weight is due almost entirely to an increase in the size and, in many cases, the numbers of corpora lutea. With continued treatment the ovaries of the splenectomized animals begin to regress rather rapidly after about 30 days, due, we believe, to the establishment of a compensatory mechanism, in the form of a hyperplasia and increased activity of the remainder of the reticulo-endothelial tissue.

The vaginal smears of the control injected animals show a condition of almost continual estrus for as long as one month after beginning injections. The smears of the splenectomized rats, although indicative of estrus for a few days after the opening of the vaginal orifice, soon become almost of the complete diestrus type and remain that way for at least a month following onset of treatment. We interpret these results as follows. The injected normal immature rat, because its reticulo-endothelial system is intact, soon produces the inhibitory principle for the luteinizing factor believed to be present in the pregnancy urine extracts. The animal's own pituitary, however, is continually producing follicular stimulating substance for which no anti-substance is formed and so the animal remains in constant estrus. This finds corroboration in sections of ovaries of all our treated controls where large follicles are always present for at least 1½ months following beginning of treatment. The splenectomized immature rat, being deprived of a large amount of reticulo-endothelial tissue, produces for a time a smaller quantity of the inhibitory substance for the luteinizing principle. More and larger corpora result, and even though mature follicles are still present, the animal lapses into diestrus because of the greater preponderance of progesterone over estrin in the circulating blood.

It is of extreme importance that the rats employed be completely free of all traces of *Bartonella muris*, a latent infection quite prevalent in rats,[2] since this necessarily affects reticulo-endothelial activity. The following experiments indicate the importance of taking this factor into account.

(1) Unoperated immature Bartonella carrier rats in response to daily injections of 10 R.U. pregnancy urine extract for 20 days develop luteinized ovaries as large as those which are present in 20-day treated Bartonella free splenectomized animals. That this response is due most likely to reticulo-endothelial block-

[1] For chief references on the subject, refer to the papers by: J. B. Collip, *Jour. Mt. Sinai Hosp.*, 1: 28, 1934; G. H. Twombly, *Endocrinol.*, 20: 311, 1936; P. A. Katzman, N. J. Wade and E. A. Doisy, *Endocrinol.*, 21: 1, 1937; K. W. Thompson and H. Cushing, *Proc. Roy. Soc.*, B, 121: 501, 1937; I. W. Rowlands, *Proc. Roy. Soc.*, B, 121: 517, 1937.

[2] D. Perla and J. Marmorston, "The Spleen and Resistance." Williams and Wilkins Co. 1935.

age by the Bartonella organism can be seen from some of our experiments, which show that if Bartonella carrier injected rats are splenectomized on the twentieth day of treatment, those which have developed the largest ovaries die within a few days, evidence of the disease being very readily revealed in the blood during this time and, in most cases, in histological sections of the excised spleen. Autopsy of these animals shows only a slight compensatory hyperplasia of the lymph and hemolymph tissue. We have had a few Bartonella carrier treated animals which did not succumb after splenectomy performed on the twentieth day of injection, but these rats are almost invariably those which have developed smaller ovaries in response to the treatment. They survive and produce the inhibitory substance to some extent, due most likely to the marked hyperplasia of the remainder of the reticulo-endothelial system, noted as an increase in the numbers and size of the lymph and hemolymph glands at autopsy of these animals sacrificed a few days after the operation.

(2) Nearly all our immature Bartonella carrier rats, if splenectomized at an early stage, are capable of surviving for at least a month. Daily doses of 10 R.U. pregnancy urine extract cause such animals to go into a condition of constant estrus. The ovaries of such animals after 20 to 25 days of injection are, in many cases, even smaller than those of the non-operated treated Bartonella free rats. Histological sections of these ovaries show large follicles and relatively few and smaller corpora lutea. Removal of the spleen serves as a stimulus for increased development and activity of the remaining reticulo-endothelial elements. Our results show that in the treated infected animals, removal of the spleen, coupled with the presence of the Bartonella organism, has evoked much greater reticulo-endothelial compensation, and in a shorter time, than in the injected splenectomized uninfected animals. The injected splenectomized Bartonella carrier immature rat, because of this vigorous rapid compensation, may therefore produce as much or even greater quantities of the inhibitory principle than similarly treated Bartonella free control rats. This would explain the constant estrus condition in such animals.

This work has theoretical importance because (1) it demonstrates a connection between reticulo-endothelial activity and the development of refractoriness to heterozoic endocrine extracts. This strongly supports the contention that the antagonistic substances produced in response to chronic treatment with such extracts are antibody-like in nature. Experiments dealing with a comparison of the neutralizing effects of serum from injected splenectomized, "reticulo-endothelial blocked" and normal animals are now being conducted. (2) It suggests that, by depressing reticulo-endothelial activity either by excision of portions or experimental blockade, it may be possible to evoke from endocrine organs physiological responses of greater magnitude than ever before. (3) It points to the necessity of taking into account the factor of latent infection prevalent in laboratory animals, in interpreting the responses from the endocrine organs. This factor may possibly account, to some extent, for the sometimes exceedingly variable results obtained with prolonged injections of endocrine principles.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW TYPE OF RELIEF MAP

IN many fields maps are absolutely indispensable in recording, understanding and demonstrating the lay of a land. Relief maps, too, have their special purpose, and contractors, architects and engineers are using them more and more the better to understand the problems depending on terrain. Even with the specialist himself, contour lines alone do not make the picture stand out in its full meaning.

It is easy to think of a contour line as the edge of a terrace or of a horizontal board; indeed, it is common practice to cut out cardboard to represent contour lines, and these are piled one on another to give actual relief features. Even without smoothing the "terrace" edges to give a uniform slope the original map may be drawn in place to represent the geographic units—roads, streams, cities and such.

Now we offer a plan of map making by which all the features may be brought into relief as if stamped out of sheet metal, and with it the streams, roads, etc., may be retained in their correct positions. This makes for accuracy and for ease in construction, since it is purely a mechanical reproduction of the original.

The procedure may be as follows. Take the regular government topographic map and have it enlarged, perhaps to four inches per mile. Secure the cardboard that happens to give the desired vertical elevation, and lay the map on a piece of board of suitable size; place this on a jig-saw and cut along the lowest contour. (For convenience mark this board No. 2.) The piece of map thus cut out represents an area of one elevation and may be pasted upon a new board (No. 1) in its proper place and put to one side.

The rest of the map should in turn be fastened to a

new board (No. 3) with thumb tacks and the next contour line cut. Now this strip of paper, cut from between the first and second contours, is carefully pasted along the edge of board No. 2, where it fits perfectly.

Repeat the process; *i.e.*, the remaining part of the map is again fastened to a new board (No. 4) and again another contour is cut out on the jig-saw and the strip is pasted to board No. 3. This is continued until the map is used up, is cut along every contour and each strip is pasted to the previous board where it belongs. Tubes of Duco cement are most convenient in pasting the strips of map to the boards.

These odd-shaped boards, each smaller than the one preceding it and of similar shape, are then put together, using the paper strips as guides; they may eventually be glued and nailed securely. The finished block with all water and cultural features appears, especially from a point directly above, as a faithful reproduction of the original map. The vertical exaggeration depends upon the thickness of the cardboard used; for instance, the two-tenths inch Upson board in connection with a twenty-foot contour map gives an inch for each hundred feet of elevation.

Certain problems arise with respect to depressions, outlying hills and such that may be separate from the main part of the map. It should be kept in mind that the contour around any such feature should be cut at the same time and from the same board as the corresponding contour in the main map.

Moreover, in a rather simple manner one may make a model in plaster as a by-product from this process. This involves saving the "waste" or "scrap-pieces" as they are cut away from each contour; they are put together, piled up to make a mold—a negative—that gives a depression where a hill existed. One should use the positive, the relief map itself, as a guide in placing the negative pieces and it should be done before the positive is glued or nailed together. The negative must be smoothed with plastic material before the casting is attempted in order to avoid the sticking of the final plaster model as it is "pulled." While such a "plaster model" is more like the natural land surface in its smooth slopes and may have the advantage of being waterproofed, yet it lacks the details of roads, cities and streams that the cardboard relief map may have.

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STARFISH STAINS

LOOSANOFF[1] has reported that starfish stained with Nilblue sulfate are apparently uninjured and retain the blue color for as long as three months. To trace migration from two separate winter concentrations in Narragansett Bay this year, experiments were carried on for the purpose of obtaining one or more additional dyes.

The first tests were made with varying concentrations, but in all cases it was found that a concentration of 1 g per liter of solution was not toxic for a short immersion period and that such a concentration was necessary to obtain staining in a period of less than five minutes. The following results are for this strength of solution.

Janus Green and Lichtgrun, made by Dr. Gruebler and Company; du Pont Brilliant Green and Malachite Green, made by the du Pont Company, and Chrome Green C. B. and Erie Green W. T., made by National Aniline Company, were the green dyes tested. The first and third stained, but the color was not lasting. The fourth stained blue, and the others did not take.

The red dyes tested were Neutral Red, made by Dr. Gruebler and Company, and Rhodamine B, made by the du Pont Company. The latter stains well, but the color fades. Neutral Red, however, stains well and the color holds.

Other dyes tested were Basic Brown, Crystal Violet and Methyl Violet, all made by the National Aniline Company. The first stained dark red, which faded slowly, while the last two faded very rapidly.

Neutral Red was selected as the most satisfactory of these dyes, and several thousand specimens have been stained and liberated in the Mount Hope Bridge region. In control live cars, there has been so far no detectable change in Neutral Red stained starfish over a period of four weeks.

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[1] Loosanoff, SCIENCE, 85: 412, 1937.

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